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### 10 TON BRIDGE CRANE AT THE VAB/LOW BAY AREAS K&L CHECKOUT CELLS 1,2 & 4

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**SYSTEM ASSURANCE ANALYSIS**  
**OF THE**  
**10 TON**  
**BRIDGE CRANES**  
**AT THE**  
**VAB LOW BAY**  
**CHECKOUT CELLS 1, 2 & 4**

BASELINE NO.: 389.00

PMN: K60-0531

Revision Log

Rev.	Description	Date
New	This SAA cancels and supercedes SAA09FY12-003. Upgraded criticality of Cell 2 & 4 cranes to perform Crit. 2 and 1 functions respectively.	6/3/91
A	Incorporated EO1 thru 4. Added final upper limit switches to all three hoists per CCBD 115451. Deleted FMN: 002.003 and .004. Removed suspended load use.	2/7/07

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## 1 SYSTEM ASSURANCE ANALYSIS SUMMARY

### 1.1 FINDINGS

**Table 1. Finding Summary**

	<u>Assessment</u>	
Reliability Criticality	Critical	
Safety Criticality	Critical	

	<u>Type</u>	<u>Quantity</u>
Critical Items	1	-
	1S	-
	2	33
1R Non-CIL Items	1R	-
Critical Flexhoses	1S	-
	2	-
Critical Orifices	1S	-
	2	-
Critical Filters	1S	-
	2	-
Hazard Reports	Accepted Risk	-
	Controlled	-

### 1.2 AREAS OF CONCERN

There were no Areas of Concern identified with this system.

### 1.3 DOCUMENTATION LIST

<u>Document/Drawing No.</u>	<u>Rev</u>	<u>Outstanding EOs or Changes</u>	<u>Title</u>
79K16767	C	-	VAB Low Bay, Cell 1, 2 & 4 10 Ton Bridge Crane
80K16827	-	-	Mechanical Arrangement 10 Ton Bridge Crane Low Bay Cells 1, 2 & 4, VAB

## 2 SYSTEM DESCRIPTION

### 2.1 GENERAL

The double girder, double rail, 10-ton bridge cranes were manufactured by Heco-Pacific Manufacturing, Inc., Union City, California, 94587. The cranes have a 49-foot span. The lowest point of the bridge structure is 40 feet above the floor of the VAB/Low Bay Areas K & L.

The cranes consist of three subsystems - hoist, trolley, and bridge. The components are electrically actuated by 3-phase, 60-hertz, 480 volt alternating current (VAC) motors. Control power is 110V ac provided through a standard push-button-equipped crane control pendant, which provides for five motor speeds. The crane

control pendant is suspended from the bridge structure via a retractable balance reel. This allows the pendant to be adjusted to a convenient height or distance from the bridge center, clear of wide loads.

The bridge travels on horizontal rails for a distance of 49 feet in an eastwest direction at speeds of 0 to 25.16 F.P.M., 5 speed variable.

The trolley is driven directly by drive wheels via a cross-shaft running on rails mounted on the bridge. The trolley travels the length of the bridge in a north-south direction, at speeds of 0 to 9.96 F.P.M., 5 speed variable. The trolley carries with it the complete hoist mechanism.

The hoisting mechanism consists of wound-rotor, variable-speed main motor, reduction gears, a brake, a rope winding drum, a two-sheave lower block, a single-sheave equalizer pulley, a steel hoisting rope, bearings and couplings. Hoisting height (hook travel from lower to upper limits) is 40 feet at 0 to 9.45 F.P.M., 5 speed variable.

All three cells (1, 2 and 4) are to be used in a contingency basis. Prior use of these cells were for processing SSMEs (cell 2 and 4) and the EDO pallet (cell 1). The cells were upgraded per CCBd 115451 to install a final upper limit switch to meet NASA-STD-8719.9.

## **2.2 MAIN HOIST ASSEMBLY**

This assembly lifts, holds and lowers the load suspended from the load hook. The unit consists of a wire rope drum, and electric driving motor, a gear reducer, an electric brake and a load brake, assembled as an integral unit along a common axis. The main hoist assembly is mounted onto a horizontal trolley, consisting of four wheels engaged into lateral bridge beam rails. The electric motor provides torque to the wire rope drum by way of a gear reducer.

A spring engaged, shoe-type motor brake is mounted at the opposite end of the drive pinion shaft. The motor brake is normally set due to spring compression and is electrically released whenever power is applied to the motor. A Weston screw-type mechanical load brake controls the lowering speed of the hoist and provides load holding ability in the event of failure of the motor or motor brake. The load brake assembly is activated while raising and lowering the load. During lowering, the action of the motor is opposite to that of the load and tends to release the brake. When the brake pressure is decreased sufficiently by the motor, the load descends. If the speed of the load begins to exceed that of the motor, the brake sets. The lowering speed is therefore always controlled by the speed of the motor.

## **2.3 TROLLEY DRIVE ASSEMBLY**

The purpose of this unit is to move the main hoist assembly laterally across the width of the test cell on the bridge beam rails. This is accomplished by applying torque to one of the trolley wheels. The assembly consists of an electric motor, an electric brake, a gear reducer assembly and a gear drive assembly. The motor is reversible and, therefore, able to drive the trolley in either direction. The drive pinion of the gear drive assembly operates against the motor gear, which is keyed directly to the trolley wheel.

The electric brake is spline-mounted to the motor shaft. When the motor is de-energized the brake solenoid also becomes de-energized, allowing the brake spring to engage the brake and hold the trolley.

## **2.4 BRIDGE DRIVE ASSEMBLY**

The purpose of this unit is to move the main hoist assembly laterally across the length of the test cell on the bridge rails. This is accomplished by applying torque to two of the four bridge beam wheels. The assembly consists of an electric motor, an electric brake, a gear reducer, and a gear drive.

The motor is reversible and, therefore, able to drive the bridge beams in either direction. The drive pinion of the gear drive assembly operates against the drive gear, which is keyed directly to the bridge wheel shaft. The bridge wheel shaft extends the length of the bridge beams and is connected at either end to the drive wheels.

The electric brake is spline-mounted to the motor to the motor shaft. When the motor is de-energized the brake solenoid also becomes de-energized, allowing the brake spring to engage the brake and hold the bridge beams.

## 2.5 PUSH-BUTTON CONTROL PENDANT

The control pendant manufactured by the Duct-O-Wire Company of Corona Calif. has four 2 button push button switch modules identified as follows:

Main Line Power	Start Stop
Hoist	Raise Lower
Trolley	Right Left
Bridge	Forward Reverse
Up Limit	Bypass Normal

The three push button switch modules operating the hoist, bridge and trolley are five speed and control the relay logic of the resistor banks to the three wound-rotor AC motors powering the hoist, bridge and trolley.

## 2.6 EMERGENCY STOP

The Crane is equipped with an emergency stop independent from the operator-controlled pendant.

## 2.7 ISOLATED CRANE HOOK ASSEMBLY

The Crane Hook is an electrically insulating type hook manufactured by Miller Manufacturing Co. As installed, the hook serves to help minimize the probability of stray voltages contacting sensitive loads. The hook is designed to maintain its isolation characteristics to 50,000 volts maximum. The hook is also fitted with a ground stud for further stray voltage protection when connected to facility ground system. In addition, this hook has a safety factor of 5 to 1.

## 2.8 ANALYSIS OF GEARBOX, SHAFT, AND GEAR RETENTION METHODS

As a point of special concern for the safety of sensitive loads, the design integrity of hoist gearboxes was carefully reviewed for failure modes that, if they should occur, could cause or contribute to dropping a load. The particular failure modes under scrutiny are:

The ability of a gear to slip out-of-mesh with its associated gear or structural failure of a gear possibly caused by:

- The gear itself slipping axially along the shaft.
- The shaft with gear firmly fixed thereon slipping axially out-of-alignment.
- Broken gear teeth or complete destruction of a gear.

The effect of such a failure occurrence would result in the load being dropped possibly causing loss of life and/or damage to the load. Neither the mechanical load brake nor the hoist motor brake could prevent a

load from being dropped under the above conditions because the affected gears are located between the brakes and rope drum.

The hoist gearbox consists of five spur gears. They are the driving pinion, the high speed gear, the intermediate pinion, the intermediate gear and pinion and the slow speed gear. The driving pinion is integrally machined on a spline shaft running through the rope drum output shaft. Hoist motor torque is transmitted from the motor through the wire rope drum by a drive shaft. The hoist motor brake is splined to the opposite end of the driving pinion shaft. The driving pinion meshes with the high speed gear. The high speed gear is part of the mechanical load brake assembly, along with the ratchet, ratchet disc, and intermediate pinion.

The intermediate pinion is an integral part of the mechanical load brake shaft that also includes the acme screw threads on which the high speed gear is threaded. Torque from the hoist motor and the load applied to the screw thread compress the ratchet between the high speed gear and the ratchet disc providing braking friction when the ratchet pawl engages the ratchet during lowering. The intermediate pinion meshes with the intermediate gear of the intermediate gear and pinion. The intermediate pinion of the intermediate gear and pinion meshes with the low speed gear. The low speed gear is splined to the drum shaft. The wire rope drum is splined to the drum shaft.

Axial slippage of gears and shafts are prevented by shoulders and the overlap of the gears themselves within the confined space of the gearbox. Bearings are supported by cups within the gearbox case structure and are retained in place by snap rings. There is insufficient space within the gear case to allow gears to slip out of mesh with each other or a shaft to pull free from a bearing.

The wire rope drum is mounted in the chassis such that drum bearing failure will not cause the load to drop. End-to-End chassis to drum clearance is insufficient to allow axial movement along the drum shaft so that the drum drive shaft will disengage from the drum.

### 3 ANALYSIS GROUND RULES

This analysis has been developed in accordance with NSTS 22206 and NSTS 22254.

The following additional groundrules and assumptions were used during this analysis:

- a. The hoist has a 5 step speed selection as follows:

SELECTION	SPEED
1ST	Static Load Holding, No Movement
2ND	< 1 FPM
3RD	4.56 FPM
4TH	7.75 FPM
5TH	9.12 FPM

There are failures that could occur where a contact could fail closed allowing the hoist to go into a higher speed bypassing a slower speed. Going from 1<sup>st</sup> speed to 4<sup>th</sup> speed if the contact for 4<sup>th</sup> speed failed closed. However the speed differentials are so close together that a jump to a higher speed will not be noticeable. Therefore, this will not be a cause for the load to move uncontrollably causing damage to flight hardware if it were in close proximity to an object.



## **4 FAILURE MODES AND EFFECTS ANALYSIS**

### **4.1 CRITICALITY ASSESSMENT AND END-TO-END ANALYSIS**

**Table 2. Criticality Assessment Worksheet – K60-0531**

Pages 9 to 9

**System/Subsystem:** VAB Low Bay Checkout Cells 1, 2 and 4 Bridge Cranes**Baseline Number:** 389.00**Location:** VAB Low Bay

<b>Input/ Output</b>	<b>Function</b>	<b>Time Period</b>	<b>Effect of Loss/Failure</b> If Function Fails to Operate or Cease Operation on Time, Fails During Operation, and/or Prematurely Operates	<b>Crit/ Noncrit</b>	<b>Notes</b>
<b><u>Input</u></b>					
Electrical Power	Provide power to move the hook, trolley and bridge.	As required	Power failure would cause a delay in processing.	NC	See SAA09ELR2-001
Operator Inputs	Controls the bridge trolley and hook.	As required	Failure to control the crane properly during operation could damage to a vehicle system.	C	See Hazard Analysis
<b><u>Output</u></b>					
Force Motion					
• Lifts and Lowers	Support of the load while being moved	As required	Failure to cease operation on time or prematurely operate could cause damage to vehicle systems.	C	See FMEA
• Left and Right	Support of the load while being moved	As required	Failure to cease operation on time or prematurely operate could cause damage to vehicle systems.	C	See FMEA
• Forward and Reverse	Support of the load while being moved	As required	Failure to cease operation on time or prematurely operate could cause damage to vehicle systems.	C	See FMEA
• Stop and Hold the Load	Support of the load while being moved	As required	Failure to stop and hold the load could cause damage to vehicle systems.	C	See FMEA
• E-Stop	Remove the power during emergency to stop all movement of the load.	During an emergency	Failure to stop the load in an emergency could cause damage to a vehicle system.	C	See FMEA

## 4.2 FMEA WORKSHEETS

The Failure Modes and Effects Analysis follows.

### 4.2.1 Passive Components

Passive items are components that may be necessary for the performance of the system but do not change state during critical operations, or static structural members that do not transfer an applied force to an object to make the object move in some manner, unless otherwise accepted in NSTS 22206 as a passive component.

The following components were considered passive in the analysis:

<b>Table 3. Passive Component List</b>	
Item	Rationale
Static Structural Components	Static structural components do not provide an active function and are considered passive per NSTS 22206 paragraph 4.4.1.a.6
Hook, Load Block, Wire Rope, Sheaves, Rope Drum, bridge and trolley wheels	These components accepted as passive per NSTS 22206 paragraph 4.5.1.g. However, the drum shafts shall be analyzed as to the attachment method.

The Hazard Analysis contains passive components that constitute a safety concern.

### 4.2.2 Wire Harnesses, Cables and Connectors

Wire harnesses, cables, and connectors were not analyzed in the FMEA Table(s) since failure of the electrical functions assessed in Section 4.1 for this system could not result in loss of life or vehicle, (Ref. NSTS 22206, Paragraph 4.4.1.b.2).

## 4.3 COMPUTER INTERFACE ANALYSIS

This system does not use an LPS, INCS, or KCCS computer interface for control and/or monitoring of critical system functions identified in Section 4.1.

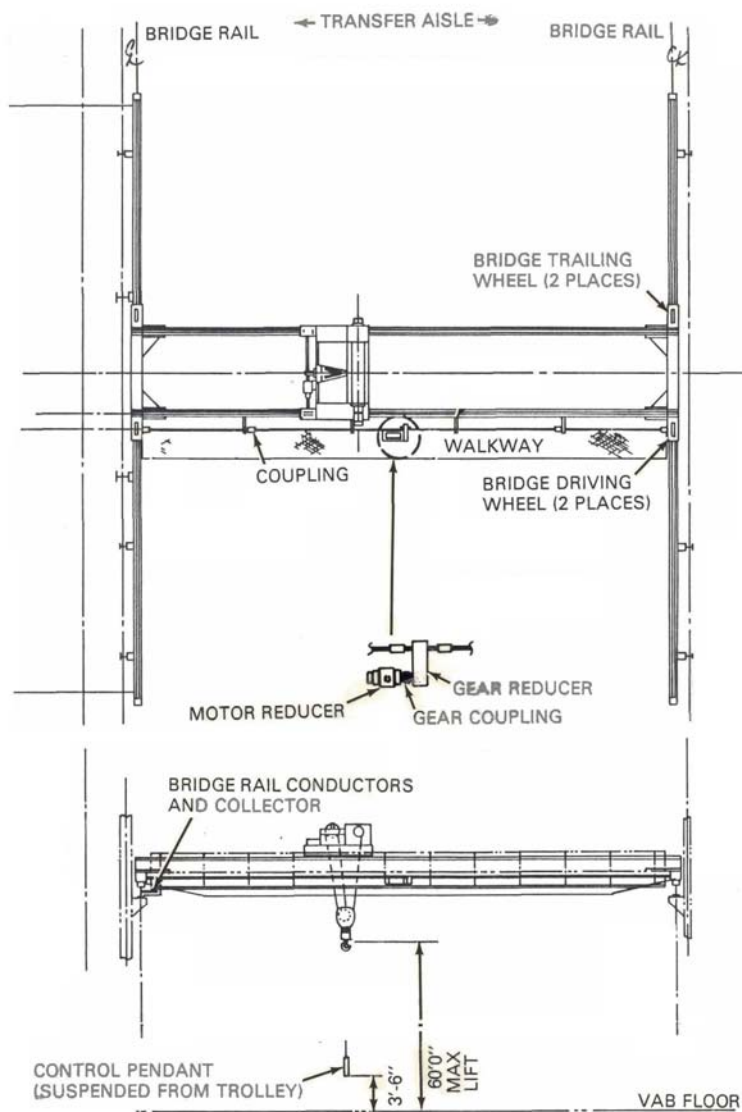


Figure 1. VAB Cell 1, 2 & 4 10 Ton Cranes

Table 4. MECHANICAL FMEA – VAB Low Bay Checkout Cells 1, 2 and 4						Pages 12 to 15
System/Subsystem: VAB Low Bay Checkout Cells 1, 2 and 4 Bridge Cranes PMN: K60-0931					Drawing No.: 79K16767 Reference: None	
Find No. Part No.	Part Name	Part Function	a. Failure Mode b. Cause c. FMN d. Detection Method e. Correcting Action f. Time to Effect g. Timeframe	Failure Effect On System Performance	Failure Effect On Vehicle Systems And/Or Personnel Safety	Crit Cat
None	Hoist Gearbox Assembly	Transmits power from the hoist motor to the wire rope drum.	a. Gear disengagement b. Structural failure of gears, shafts, mechanical load brake components, and the gearbox housing c. 09FY121-002.001 d. Abnormal noises and movements e. None f. Seconds g. NA	Load (Flight Hardware) suspended from hoist will drop.	Failure could result loss (damage) to flight hardware.	2
None	Mechanical Load Brake assembly	The mechanical Load brake holds the load after hoisting as well as controlling the speed during lowering.	Mechanical load brake fails to set	Motor brake is the primary brake. Motor brake will stop and hold load when power is removed by releasing the down button.	No effect.	3
None	Hoist motor Brake Assembly	Device that provides mechanical braking of the hoist. Braking occurs upon removal of power.	Brake does not release	Hoist will not operate.	No effect.	3
			Motor brake fails to set	Mechanical load brake will hold the load. Mechanical load brake will stop and hold load when power is removed by releasing the down button.	No effect.	3
None	Spider assembly (U-joint) (2 items)	Transmits motor Torque to and from The drive shaft. Compensates for Misalignment	Structural failure	Hoist will not operate. Motor brake and mechanical load brake will hold load.	No effect.	3

Table 4. MECHANICAL FMEA – VAB Low Bay Checkout Cells 1, 2 and 4						Pages 12 to 15
System/Subsystem: VAB Low Bay Checkout Cells 1, 2 and 4 Bridge Cranes PMN: K60-0931					Drawing No.: 79K16767 Reference: None	
Find No. Part No.	Part Name	Part Function	a. Failure Mode b. Cause c. FMN d. Detection Method e. Correcting Action f. Time to Effect g. Timeframe	Failure Effect On System Performance	Failure Effect On Vehicle Systems And/Or Personnel Safety	Crit Cat
2	Trolley helical gear parallel shaft reducer	Provide power linkage and mechanical advantage from motor reducer to trolley wheels.	Gear disengages	Trolley stationary: unable to move trolley. Trolley in motion, loss of trolley drive and brake. Weight of trolley assembly will stop motion of trolley immediately.	No effect.	3
3	Trolley double reduction helical gear motor reducer and brake	Provide locomotion for trolley assembly in left/right direction. Transmit power from trolley drive motor to trolley gear drive, reduce motor rotation speed trolley	Mechanical failure of motor	Unable to move trolley.	No effect.	3
			Reducer gear disengages	Trolley stationary: unable to move trolley. Trolley in motion: loss of trolley drive and brake. Weight of trolley assembly would stop motion of trolley immediately.	No effect.	3
			Motor brake fails to release	Unable to move trolley.	No effect.	3
			Motor brake fails to set	Loss of trolley brake. Weight of trolley assembly would stop motion of trolley immediately.	No effect.	3
4	Standard flex gear (2) (coupling)	Provide power linkage from trolley gear reducer to drive wheels.	Structural failure	Loss of torque to one drive wheel. Trolley may still operate.	No effect.	3

Table 4. MECHANICAL FMEA – VAB Low Bay Checkout Cells 1, 2 and 4						Pages 12 to 15
System/Subsystem: VAB Low Bay Checkout Cells 1, 2 and 4 Bridge Cranes PMN: K60-0931					Drawing No.: 79K16767 Reference: None	
Find No. Part No.	Part Name	Part Function	a. Failure Mode b. Cause c. FMN d. Detection Method e. Correcting Action f. Time to Effect g. Timeframe	Failure Effect On System Performance	Failure Effect On Vehicle Systems And/Or Personnel Safety	Crit Cat
5	Standard flex Gear (coupling)	Provide power linkage from trolley motor reducer to gear reducer.	Structural failure	Unable to move trolley.	No effect.	3
6	Trolley assembly	Support hoist assembly, provide right/left movement	Wheel bearing seizure	Impart higher torque load into trolley drive train. Possible damage to trolley drive.	No effect.	3
7	Bridge single reduction helical motor reducer and brake	Provide location for bridge assembly in forward/reverse direction.	Mechanical failure of motor	Unable to move bridge.	No effect.	3
			Gear disengages	Bridge stationary: unable to move bridge. Bridge in motion: loss of bridge drive and brake. Weight of bridge crane should stop motion of bridge immediately.	No effect.	3
			Motor brake fails to release	Unable to move trolley.	No effect.	3
			Motor brake fails to set	Loss of bridge brake. Weight of bridge crane should stop motion of bridge immediately.	No effect.	3
8	Bridge reducer	Provide power linkage and mechanical advantage from gear reducer to bridge drive wheels.	Gear disengages	Bridge stationary: unable to move bridge. Bridge in motion: loss of bridge drive and brake. Weight of bridge crane should stop motion of bridge immediately.	No effect.	3

Table 4. MECHANICAL FMEA – VAB Low Bay Checkout Cells 1, 2 and 4						Pages 12 to 15
System/Subsystem: VAB Low Bay Checkout Cells 1, 2 and 4 Bridge Cranes PMN: K60-0931					Drawing No.: 79K16767 Reference: None	
Find No. Part No.	Part Name	Part Function	a. Failure Mode b. Cause c. FMN d. Detection Method e. Correcting Action f. Time to Effect g. Timeframe	Failure Effect On System Performance	Failure Effect On Vehicle Systems And/Or Personnel Safety	Crit Cat
9	Pillow block	Support bridge drive shaft and maintain alignment.	Bearing seizure	Impart higher torque load into bridge drive train. Possible damage to bridge drive.	No effect.	3
10	Standard gear coupling	Provide power linkage from bridge drive shaft to bridge drive wheels.	Structural failure	Loss of torque to one drive wheel. Bridge may still operate.	No effect.	3
11	Standard gear coupling	Provide power linkage from motor reducer to bridge reducer.	Structural failure	Unable to move bridge.	No effect.	3
12	Ribbed compression	Provide power linkage from the bridge reducer to the bridge drive shafts and between bridge drive shaft sections.	Structural failure	Loss of torque to one drive wheel. Bridge may still operate.	No effect.	3
None	Bridge assembly	Support hoist / trolley assembly, provide forward / reverse movement.	Wheel bearings seizure	Impart higher torque load in bridge drive train. Possible damage to bridge drive.	No effect.	3



Table 5. ELECTRICAL FMEA - VAB Low Bay Checkout Cells 1, 2 and 4						Pages 16 to 41
System/Subsystem: VAB Low Bay Checkout Cells 1, 2 and 4 Bridge Cranes/Electrical PMN: K60-0391					Drawing No.: 79K16767 Reference: None	
Find No. Part No.	Part Name	Part Function	a. Failure Mode b. Cause c. FMN d. Detection Method e. Correcting Action f. Time to Effect g. Timeframe	Failure Effect On System Performance	Failure Effect On Vehicle Systems And/Or Personnel Safety	Crit Cat
GULS GLLS	Hoist geared limit switch assembly, upper and lower.	Opens hoist motor circuit when hoist travel exceeds the preset limits of travel	Fails open	Hoist will not operate in the direction effected.	No effect.	3
			Fails closed	Hoist will not stop at preset limit of travel. However, redundancy is provided for upper limits. In lower limits this failure could occur undetected because the load will normally meet the floor surface before the limit switch actuates.	No effect.	3
LS-B	Bridge limit switch, 3 pos.	Opens bridge control circuit when bridge exceeds preset limits of travel in either forward or reverse directions.	Fails open (any one)	Bridge motor will not operate.	No effect.	3
			Fails closed (any one)	Bridge will not stop at preset limits of travel until commanded or until mechanical stops are contacted.	No effect.	3
LS-T	Trolley limit switch, 3 pos.	Opens trolley control circuit, when trolley exceeds preset limits of travel in either left or right directions.	Fails open (any one)	Trolley motor will not operate.	No effect.	3
			Fails closed (any one)	Trolley will not stop at preset limits of travel until commanded or until mechanical stops are contacted.	No effect.	3

Table 5. ELECTRICAL FMEA - VAB Low Bay Checkout Cells 1, 2 and 4						Pages 16 to 41
System/Subsystem: VAB Low Bay Checkout Cells 1, 2 and 4 Bridge Cranes/Electrical PMN: K60-0391					Drawing No.: 79K16767 Reference: None	
Find No. Part No.	Part Name	Part Function	a. Failure Mode b. Cause c. FMN d. Detection Method e. Correcting Action f. Time to Effect g. Timeframe	Failure Effect On System Performance	Failure Effect On Vehicle Systems And/Or Personnel Safety	Crit Cat
CT	Transformer, 480-120V	Provides stepped down power source for control logic.	Fails open	All crane functions will be lost. Hoist, trolley and bridge will not operate.	No effect.	3
			Fails shorted	All crane functions will be lost. Hoist, trolley and bridge will not operate.	No effect.	3
S1	Switch, pushbutton (remote stop)	Removes 120V AC from control circuit and de- energizes motor contactor.	Fails open	All crane functions will be lost. Hoist, trolley and bridge will not operate.	No effect.	3
			Fails closed	Remote stop capability lost. Failure undetectable until use is attempted. Normal stop function is unaffected. Prior failure resulting in uncontrolled motion required.	No effect.	3
S2	Switch, (stop)	Removes 120V AC from control circuit and de- energizes motor contactor.	Fails open	All crane functions will be lost. Hoist, trolley and bridge will not operate.	No effect.	3
			Fails closed	Local stop function lost. Power cannot be removed from motor contactor or logic circuits. Redundancy is provided (S1).	No effect.	3
S10	Switch (start)	Energizes main line contactor and provides power to control circuits.	Fails open	All crane functions will be lost. Hoist, trolley and bridge will not operate. No effect if failure occurs during operation.	No effect.	3

Table 5. ELECTRICAL FMEA - VAB Low Bay Checkout Cells 1, 2 and 4						Pages 16 to 41
System/Subsystem: VAB Low Bay Checkout Cells 1, 2 and 4 Bridge Cranes/Electrical PMN: K60-0391					Drawing No.: 79K16767 Reference: None	
Find No. Part No.	Part Name	Part Function	a. Failure Mode b. Cause c. FMN d. Detection Method e. Correcting Action f. Time to Effect g. Timeframe	Failure Effect On System Performance	Failure Effect On Vehicle Systems And/Or Personnel Safety	Crit Cat
M	Relay, mainline contactor	Switches 480V 3 phase power to hoist, trolley, and bridge motor control relays.	Fails closed	Motor contactor will remain energized. Continuous power supplied to logic circuits.	No effect.	3
			Relay fails open/short	All crane functions will be lost. Hoist, trolley and bridge will not operate	No effect.	3
			Aux. contact fails open	Mainline will not remain energized when S10 is released.	No effect.	3
			Aux. contact fails closed	Mainline will be energized without S10. S2 is stop will keep the circuit open.	No effect.	3
			Contact fails open (motor power)	Cannot run the hoist.	No effect.	3
S4	Push-button switch	Energizes control relays for up hoist function	Contact fails closed (motor power)	No effect. PSR will stop the hoist power if not all three contacts are closed. Need contact U or D closed also to run the hoist. Several failures required.	No effect.	3
			Fails open	Hoist will not operate upward.	No effect.	3
			Fails closed	Hoist will not cease operation in upward direction unless commanded by the stop, remote stop, disconnect switches or upper limit switches.	No effect.	3

Table 5. ELECTRICAL FMEA - VAB Low Bay Checkout Cells 1, 2 and 4						Pages 16 to 41
System/Subsystem: VAB Low Bay Checkout Cells 1, 2 and 4 Bridge Cranes/Electrical PMN: K60-0391					Drawing No.: 79K16767 Reference: None	
Find No. Part No.	Part Name	Part Function	a. Failure Mode b. Cause c. FMN d. Detection Method e. Correcting Action f. Time to Effect g. Timeframe	Failure Effect On System Performance	Failure Effect On Vehicle Systems And/OR Personnel Safety	Crit Cat
S5	Push-button switch, (hoist down)	Energizes control relays for down hoist function	Fails open  a. Fails closed b. Switch sticks, hoist function, welded contacts, broken spring c. 09FY121-002.005 d. Motion fails to stop when commanded e. NA f. Seconds g. NA	Hoist will not operate downward.  Hoist will not cease operation in "downward" direction unless commanded by the stop, remote stop, disconnect switches or limit switch. Close proximity to an obstruction may not allow sufficient time for the operator to use e-stop.	No effect.  Possible damage to flight hardware.	3  2
S6	Pushbutton switch (trolley right)	Energizes control relays for trolley "right" function	a. Fails closed b. Switch sticks, (trolley- welded contacts, broken spring c. 09FY121-002.005 d. Visual e. NA f. Seconds g. NA  Fails open	Trolley will not cease operation in "right" direction unless commanded by the stop, remote stop, disconnect switches or limit switch. Close proximity to an obstruction may not allow sufficient time for the operator to use e-stop.  Trolley will not operate in the "right" direction.	Possible damage to flight hardware.  No effect.	2  3

Table 5. ELECTRICAL FMEA - VAB Low Bay Checkout Cells 1, 2 and 4						Pages 16 to 41
System/Subsystem: VAB Low Bay Checkout Cells 1, 2 and 4 Bridge Cranes/Electrical PMN: K60-0391					Drawing No.: 79K16767 Reference: None	
Find No. Part No.	Part Name	Part Function	a. Failure Mode b. Cause c. FMN d. Detection Method e. Correcting Action f. Time to Effect g. Timeframe	Failure Effect On System Performance	Failure Effect On Vehicle Systems And/Or Personnel Safety	Crit Cat
S7	Pushbutton switch (trolley left)	Energizes control relays for trolley, "left" function.	a. Fails closed b. Switch sticks, welded contacts, broken springs c. 09FY121-002.005 d. Motion fails to stop when commanded e. NA f. Seconds g. NA	Trolley will not cease operation in "left" direction unless commanded by the stop, remote stop, disconnect switches or limit switch. Close proximity to an obstruction may not allow sufficient time for the operator to use e-stop.	Possible damage to flight hardware.	2
			Fails open	Trolley will not operate in the "left" direction.	No effect.	3
S8	Switch, pushbutton (bridge forward)	Energizes control relays for bridge "forward" function.	a. Fails closed b. Switch sticks, welded contacts, broken spring c. 09FY121-002.005 d. Motion fails to stop when commanded e. NA f. Seconds g. NA	Bridge will not cease operation in "forward" direction unless commanded by the stop, remote stop, disconnect switches or limit switch. Close proximity to an obstruction may not allow sufficient time for the operator to use e- stop.	Possible damage to flight hardware.	2
			Fails open	Bridge will not operate in the forward mode.	No effect.	3

Table 5. ELECTRICAL FMEA - VAB Low Bay Checkout Cells 1, 2 and 4						Pages 16 to 41
System/Subsystem: VAB Low Bay Checkout Cells 1, 2 and 4 Bridge Cranes/Electrical PMN: K60-0391					Drawing No.: 79K16767 Reference: None	
Find No. Part No.	Part Name	Part Function	a. Failure Mode b. Cause c. FMN d. Detection Method e. Correcting Action f. Time to Effect g. Timeframe	Failure Effect On System Performance	Failure Effect On Vehicle Systems And/Or Personnel Safety	Crit Cat
S9	Switch, pushbutton (bridge reverse)	Energizes control relays for bridge "reverse" function.	a. Fails closed b. Switch sticks, welded contacts, broken spring c. 09FY121-002.005 d. Motion fails to stop when commanded e. NA f. Seconds g. NA	Bridge will not cease operation in reverse direction unless commanded by the stop, remote stop, disconnect operator to react. Switches or limit switch. Close proximity to an obstruction may not allow sufficient time for the operator to use e-stop.	Possible damage to flight hardware.	2
UV	Under voltage relay,	Interrupts 120V AC to motor contactor in the event of an undervoltage condition of the cranes primary input power. Also closes contact to alarm	Fails open	Bridge will not operate in the reverse mode.	No effect.	3
			Fails closed	Possible damage to motor windings and/or resistor bank. May occur undetected. Requires dual failure.	No effect.	3
			Fails open	All crane functions will be lost. Hoist, trolley, and bridge will not operate.	No effect.	3
PSR	Phase sequence relay	Interrupts 120 AC to motor contactor relay in the event that input 480V AC is phased incorrectly.	Fails closed	Motors in hoist, trolley and bridge may operate in reverse direction than commanded. May occur undetected. Requires dual failure.	No effect.	3
			Fails open	All crane functions will be lost. Hoist, trolley, and bridge will not operate.	No effect.	3

Table 5. ELECTRICAL FMEA - VAB Low Bay Checkout Cells 1, 2 and 4						Pages 16 to 41
System/Subsystem: VAB Low Bay Checkout Cells 1, 2 and 4 Bridge Cranes/Electrical PMN: K60-0391					Drawing No.: 79K16767 Reference: None	
Find No. Part No.	Part Name	Part Function	a. Failure Mode b. Cause c. FMN d. Detection Method e. Correcting Action f. Time to Effect g. Timeframe	Failure Effect On System Performance	Failure Effect On Vehicle Systems And/Or Personnel Safety	Crit Cat
HOL	Hoist thermal overload relay	Interrupts 480 AC to hoist motor windings in the event of an over temperature condition. Interrupts power to the control cabinet relays.	Fails closed	Possible damage to hoist motor components due to overheating. May occur undetected. Requires dual failure.	No effect.	3
HOLF	Hoist magnetic overload relay	In the event of an overcurrent condition actuates alarm.	Fails open	Hoist motor will not operate.	No effect.	3
			Relay fails open	Hoist will not operate.	No effect.	3
			Relay fails short	Alarm will not sound.	No effect.	3
			Contact fails open	Alarm will not sound.	No effect.	3
			Contact fails closed	Alarm will always be on. Nuisance only.		
TOL	Trolley thermal overload relay (Trolley)	Interrupts 480 AC to trolley motor windings in the event of an over current condition. Interrupts power to the trolley control relays.	Fails closed	Possible damage to trolley motor components due to overheating. Requires dual failure.	No effect.	3
			Fails open	Trolley motor will not operate.	No effect.	3
TOLF	Trolley magnetic overload relay	In the event of an overcurrent condition actuates alarm.	Relay fails short	Trolley will not operate.	No effect.	3
			Relay fails open	Alarm will not sound.	No effect.	3

Table 5. ELECTRICAL FMEA - VAB Low Bay Checkout Cells 1, 2 and 4						Pages 16 to 41
System/Subsystem: VAB Low Bay Checkout Cells 1, 2 and 4 Bridge Cranes/Electrical PMN: K60-0391				Drawing No.: 79K16767 Reference: None		
Find No. Part No.	Part Name	Part Function	a. Failure Mode b. Cause c. FMN d. Detection Method e. Correcting Action f. Time to Effect g. Timeframe	Failure Effect On System Performance	Failure Effect On Vehicle Systems And/Or Personnel Safety	Crit Cat
BOL	Thermal overload bridge	Interrupts 480 AC to bridge motor windings in the event of an over current condition. Interrupts power to the bridge control relays.	Contact fails open	Alarm will not sound.	No effect.	3
			Contact fails closed	Alarm will always be on. Nuisance only.	No effect.	3
			Fails closed	Possible damage to bridge motor components due to overheating. Requires dual failure.	No effect.	3
BOLF	Bridge magnetic overload relay	In the event of an overcurrent condition actuates alarm.	Fails open	Bridge motor will not operate.	No effect.	3
			Relay fails open	Bridge will not operate.	No effect.	3
			Relay fails short	Alarm will not sound.	No effect.	3
U	Contactor relay (hoist)	Provides 480v ac power to hoist motor in "up" mode	Contact fails open	Alarm will not sound.	No effect.	3
			Contact fails closed	Alarm will always be on. Nuisance only.	No effect.	3
			All contacts fails closed	Hoist will operate upward slow whenever start button is depressed. Up motion would not cause damage to flight hardware.	No effect.	3
			All contacts fails open	Stop button or remote stop button will terminate power.  Hoist will not operate in the "up" mode.	No effect.	3



Table 5. ELECTRICAL FMEA - VAB Low Bay Checkout Cells 1, 2 and 4						Pages 16 to 41
System/Subsystem: VAB Low Bay Checkout Cells 1, 2 and 4 Bridge Cranes/Electrical PMN: K60-0391					Drawing No.: 79K16767 Reference: None	
Find No. Part No.	Part Name	Part Function	a. Failure Mode b. Cause c. FMN d. Detection Method e. Correcting Action f. Time to Effect g. Timeframe	Failure Effect On System Performance	Failure Effect On Vehicle Systems And/Or Personnel Safety	Crit Cat
D 2200R- EBR230AA	Contactor relay (hoist)	Provides 480v ac power to hoist motor in "down" mode	Any one contact fails open	Hoist will not operate in the "up" mode. Not enough power to move the hoist.	No effect.	3
			Any one contact fails closed	Hoist will not operate in the "up" mode.	No effect.	3
			Relay fails open / short	Hoist will not operate in the "up" mode.	No effect.	3
			N. C. contact fails open	Hoist will not operate in the "down" mode.	No effect.	3
			N. C. contact fails closed	Loss of safety contact. Requires dual failure.	No effect.	3
			a. All Relay contactors fail activated b. Relay sticks welded contacts. c. 09FY21-002.006 d. Motion fails to stop when commanded e. None f. Seconds g. NA	Hoist will operate downward slow whenever start button is depressed or continue to operate at minimum speed when down button is released. Stop button must be depressed to deactivate. Close proximity to an obstruction may not allow sufficient time for the operator to use e-stop.	Possible damage to flight hardware.	2
			All contacts fails open	Hoist will not operate in the "down" mode.	No effect.	3
			Any one contact fails closed	Hoist will not move. The brake would not release. Brake is 2-phase brake.	No effect.	3

**Table 5. ELECTRICAL FMEA - VAB Low Bay Checkout Cells 1, 2 and 4**

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**System/Subsystem:** VAB Low Bay Checkout Cells 1, 2 and 4 Bridge Cranes/Electrical  
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Find No. Part No.	Part Name	Part Function	a. Failure Mode b. Cause c. FMN d. Detection Method e. Correcting Action f. Time to Effect g. Timeframe	Failure Effect On System Performance	Failure Effect On Vehicle Systems And/Or Personnel Safety	Crit Cat
TR 2200R- EBR230AA	Contactor relay (Trolley)	Provides 480V AC power to trolley motor in "right" mode.	Any one contacts fails open	Hoist may operate downward whenever start button is depressed. However it will be at a very slow speed not enough to cause hardware damage.	No effect.	3
			Relay fails open / short	Hoist will not operate in the "down" mode.	No effect.	3
			N. C. contact fails open	Hoist will not operate in the "up" mode.	No effect.	3
			N. C. contact fails closed	Loss of safety contact. Requires dual failure.	No effect.	3
			a. All contacts fail closed b. Relay sticks/welded contact c. 09FY121-002.006 d. Motion fails to stop when commanded e. NA f. Seconds g. NA	Trolley will operate "right" whenever start button is depressed or continue to operate at minimum speed when trolley right button is released. Close proximity to an obstruction may not allow sufficient time for the operator to use e-stop.	Possible damage to flight hardware.	2
			All Contacts fail open	Trolley will not operate in the "right" mode.	No effect.	3
			Any one contact fails closed	Trolley will not move. The brake would not release. Brake is 3-phase brake.	No effect.	3
			Any one contacts fails open	Trolley may move right whenever start button is depressed. However, it will be at a very slow speed not enough to cause hardware damage.	No effect.	3

Table 5. ELECTRICAL FMEA - VAB Low Bay Checkout Cells 1, 2 and 4						Pages 16 to 41
System/Subsystem: VAB Low Bay Checkout Cells 1, 2 and 4 Bridge Cranes/Electrical PMN: K60-0391					Drawing No.: 79K16767 Reference: None	
Find No. Part No.	Part Name	Part Function	a. Failure Mode b. Cause c. FMN d. Detection Method e. Correcting Action f. Time to Effect g. Timeframe	Failure Effect On System Performance	Failure Effect On Vehicle Systems And/Or Personnel Safety	Crit Cat
TL 2200R- EBR230AA	Contactor relay (Trolley)	Provides 480V AC power to trolley motor in "left" mode.	Relay fails open / short	Trolley will not operate in the "right" mode.	No effect.	3
			N. C. contact fails open	Hoist will not move "left".	No effect.	3
			N. C. contact fails closed	Loss of safety contact. Requires dual failure.	No effect.	3
			a. All contacts fail closed b. Relay sticks/welded contact c. 09FY121-002.006 d. Motion fails to stop when commanded e. NA f. Seconds g. NA	Trolley will operate "left" whenever the start button is depressed or continue to move left at minimum speed when trolley left button is released. Close proximity to an obstruction may not allow sufficient time for the operator to use e-stop.	Possible damage to flight hardware.	2
			All contacts fail open	Trolley will not operate in the "left" mode.	No effect.	3
			Any one contact fails closed	Trolley will not move. The brake would not release. Brake is 3-phase brake.	No effect.	3
			Any one contacts fails open	Trolley may move left whenever start button is depressed. However, it will be at a very slow speed not enough to cause hardware damage.	No effect.	3
			Relay fails open / short	Trolley will not move "left" mode.	No effect.	3
			N. C. contact fails open	Trolley will not move "right".	No effect.	3

Table 5. ELECTRICAL FMEA - VAB Low Bay Checkout Cells 1, 2 and 4						Pages 16 to 41
System/Subsystem: VAB Low Bay Checkout Cells 1, 2 and 4 Bridge Cranes/Electrical PMN: K60-0391					Drawing No.: 79K16767 Reference: None	
Find No. Part No.	Part Name	Part Function	a. Failure Mode b. Cause c. FMN d. Detection Method e. Correcting Action f. Time to Effect g. Timeframe	Failure Effect On System Performance	Failure Effect On Vehicle Systems And/Or Personnel Safety	Crit Cat
BF 2200R- EBR230AA	Contactor relay (bridge)	Provides 480V AC power to bridge motor in "forward" mode.	N. C. contact fails closed	Loss of safety contact. Requires dual failure.	No effect.	3
			a. All contacts fail closed b. Relay sticks/welded contact c. 09FY121-002.006 d. Motion fails to stop when commanded e. NA f. Seconds g. NA	Bridge will operate "forward" whenever start button is depressed or continue to move forward at minimum speed when bridge forward button is released. Close proximity to an obstruction may not allow sufficient time for the operator to use e-stop.	Possible damage to flight hardware.	2
			All contacts fail open	Bridge will not operate in "forward" mode.	No effect.	3
			Any one contact fails closed	Bridgewill not move. The brake would not release. Brake is 3-phase brake.	No effect.	3
			Any one contacts fails open	Bridge may move forward whenever start button is depressed. However, it will be at a very slow speed not enough to cause hardware damage.	No effect.	3
			Relay fails open / short	Trolley will not move "forward".	No effect.	3
			N. C. contact fails open	Trolley will not move in "reverse".	No effect.	3
			N. C. contact fails closed	Loss of safety contact. Requires dual failure.	No effect.	3

Table 5. ELECTRICAL FMEA - VAB Low Bay Checkout Cells 1, 2 and 4						Pages 16 to 41
System/Subsystem: VAB Low Bay Checkout Cells 1, 2 and 4 Bridge Cranes/Electrical PMN: K60-0391				Drawing No.: 79K16767 Reference: None		
Find No. Part No.	Part Name	Part Function	a. Failure Mode b. Cause c. FMN d. Detection Method e. Correcting Action f. Time to Effect g. Timeframe	Failure Effect On System Performance	Failure Effect On Vehicle Systems And/Or Personnel Safety	Crit Cat
BR 2200R- EBR230AA	Contactor relay (bridge)	Provides 480V AC power to bridge motor in "reverse" mode.	a. Fails activated b. Relay sticks/welded contact c. 09FY121-002.006 d. Motion fails to stop when commanded e. NA f. Seconds g. NA	Bridge will operate "reverse" whenever start button is depressed or continue to move in reverse when bridge reverse button is released. Close proximity to an obstruction may not allow sufficient time for the operator to use e-stop.	Possible damage to flight hardware.	2
			All contacts fail open	Bridge will not operate in "reverse" mode.	No effect.	3
			Any one contact fails closed	Bridge will not move. The brake would not release. Brake is 3-phase brake.	No effect.	3
			Any one contacts fails open	Bridge may move reverse whenever start button is depressed. However, it will be at a very slow speed not enough to cause hardware damage.	No effect.	3
			Relay fails open / short	Bridge will not operate in "reverse" mode.	No effect.	3
			N. C. contact fails open	Bridge will not move "forward".	No effect.	3
			N. C. contact fails open	Loss of safety contact. Requires dual failure.	No effect.	3

**Table 5. ELECTRICAL FMEA - VAB Low Bay Checkout Cells 1, 2 and 4**

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**System/Subsystem:** VAB Low Bay Checkout Cells 1, 2 and 4 Bridge Cranes/Electrical  
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Find No. Part No.	Part Name	Part Function	a. Failure Mode b. Cause c. FMN d. Detection Method e. Correcting Action f. Time to Effect g. Timeframe	Failure Effect On System Performance	Failure Effect On Vehicle Systems And/Or Personnel Safety	Crit Cat
DS-1	Switch disconnect (main power switch)	Interrupts 480V primary power to 10 ton cane. First, downstream disconnect from facility power panel.	Fails open	All crane functions will be lost. Hoist, trolley, and bridge will not operate.	No effect.	3
			Fails closed	Loss of ability to disconnect primary power at closest point to operator. Power shut-off must occur at facility power panel.	No effect.	3
DS-2	Switch disconnect (main disconnect switch)	Interrupts 480V primary power to crane system. Electrically upstream of feedrails. Second downstream disconnect from facility power panel.	Fails open	All crane functions will be lost. Hoist, trolley, and bridge will not operate.	No effect.	3
			Fails closed	Ability to disconnect primary power upstream of feed rails will be lost. Power shut-off must occur at facility power panel.	No effect.	3
DS-3	Switch disconnect (main disconnect mounted on walkway)	Interrupts 480V primary power to crane system. Electrically upstream of feedrails. Third downstream disconnect from facility power panel.	Fails open	All crane functions will be lost. Hoist, trolley, and bridge will not operate.	No effect.	3
			Fails closed	Ability to disconnect primary power upstream of feed rails will be lost. Power shut-off must occur at facility power panel.	No effect.	3

Table 5. ELECTRICAL FMEA - VAB Low Bay Checkout Cells 1, 2 and 4						Pages 16 to 41
System/Subsystem: VAB Low Bay Checkout Cells 1, 2 and 4 Bridge Cranes/Electrical PMN: K60-0391				Drawing No.: 79K16767 Reference: None		
Find No. Part No.	Part Name	Part Function	a. Failure Mode b. Cause c. FMN d. Detection Method e. Correcting Action f. Time to Effect g. Timeframe	Failure Effect On System Performance	Failure Effect On Vehicle Systems And/Or Personnel Safety	Crit Cat
Gong	Alarm	Audible alarm to signal actuation of overcurrent sensing relays in hoist, trolley, and bridge motor circuits.	Inoperative	No audible indication of overcurrent relay actuation in hoist, trolley, or bridge. May occur undetected, but, obvious degradation of system performance will alert operator of malfunction. Overcurrent relays will disable malfunctioning circuit and preclude continued operation during an overcurrent condition.	No effect.	3
FU1	Fuse 1.4A	Current protection for control logic circuit.	Fails open	Loss of power to control circuits. Crane will not function.	No effect.	3
			Fails closed	Circuits protected by upstream breakers in facility power panel.	No effect.	3
FU2	Fuse 3A	Current protection for trolley motor circuit.	Fails open	Loss of power to trolley control circuits. Trolley will not operate.	No effect.	3
			Fails closed	Loss of current overload protection. Circuit protected by upstream breaker. Requires double failure.	No effect.	3
FU3	Fuse 3A	Current protection for bridge motor circuit.	Fails open	Loss of power to bridge control circuits. Bridge will not operate.	No effect.	3
			Fails closed	Loss of current overload protection. Circuit protected by upstream breakers. Requires dual failure.	No effect.	3

**Table 5. ELECTRICAL FMEA - VAB Low Bay Checkout Cells 1, 2 and 4**

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**System/Subsystem:** VAB Low Bay Checkout Cells 1, 2 and 4 Bridge Cranes/Electrical  
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Find No. Part No.	Part Name	Part Function	a. Failure Mode b. Cause c. FMN d. Detection Method e. Correcting Action f. Time to Effect g. Timeframe	Failure Effect On System Performance	Failure Effect On Vehicle Systems And/Or Personnel Safety	Crit Cat
HRB	Resistor bank (hoist)	Provides torque/ speed control. Electrically and incrementally as pushbuttons S4-S5 are depressed	Any one leg fails open	Leg M1 or M2, total loss of speed 1. Leg M3 speeds 2-5 slower than normal. Relay logic may bypass open as higher speeds are selected.	No effect.	3
			Any one leg fails shorted	Selected speed may be higher than normal. Relay logic may bypass short as higher speeds are selected.	No effect.	3
TRB	Resistor bank (trolley)	Provides torque/ speed control. Electrically and incrementally bypassed as pushbuttons S6 and S7 are depressed.	Any one leg fails open	Leg M1 or M2, total loss of speed 1. Leg M3 speeds 2-5 slower than normal. Relay logic may bypass open as higher speeds are selected.	No effect.	3
			Any one leg fails shorted	Selected speed may be higher than normal. Relay logic may bypass short as higher speeds are selected.	No effect.	3
BRB	Resistor bank (bridge)	Provides torque/ speed control. Electrically and incrementally bypassed as pushbuttons S8 or S9 are depressed.	Any one leg fails open	Leg M1 or M2, total loss of speed 1. Leg M3 speeds 2-5 slower than normal. Relay logic may bypass open as higher speeds are selected.	No effect.	3
			Any one leg fails shorted	Selected speed may be higher than normal. Relay logic may bypass short as higher speeds are selected.	No effect.	3
2A	Contact relay (hoist) Speed-2	Resistor bank bypass	Relay fails open / short	Loss of speed 2.	No effect.	3



Table 5. ELECTRICAL FMEA - VAB Low Bay Checkout Cells 1, 2 and 4						Pages 16 to 41
System/Subsystem: VAB Low Bay Checkout Cells 1, 2 and 4 Bridge Cranes/Electrical PMN: K60-0391					Drawing No.: 79K16767 Reference: None	
Find No. Part No.	Part Name	Part Function	a. Failure Mode b. Cause c. FMN d. Detection Method e. Correcting Action f. Time to Effect g. Timeframe	Failure Effect On System Performance	Failure Effect On Vehicle Systems And/Or Personnel Safety	Crit Cat
TD	Time delay relay (hoist) speed-3	Time delay for resistor bank bypass	Either contact fails closed	No effect. Dual failure of both contacts required.	No effect.	3
			Either contact fails open	Loss of speed 2.	No effect.	3
			Relay fails open / short	Loss of speeds 3, 4, & 5.	No effect.	3
			Contact fails open	Loss of speeds 3, 4, & 5.	No effect.	3
			Contact fails closed	Speeds 1 & 2 bypassed during startup to acceleration to speeds 3-5. Speed 2 bypassed when going from speed 1 to speeds 3 to 5.	No effect.	3
3A	Relay, contactor (hoist) (speed 3)	Resistor bank bypass	Relay fails open / short	Loss of speed 3. Other speeds unaffected.	No effect.	3
			All contacts fails closed	Hoist may operate at higher speed than commanded. Hoist will operate at speed 3 when speed 1, 2 or 3 is commanded. Speed 4 and 5 unaffected. See groundrule 3a.	No effect.	3
			All contacts fails open	Loss of speed 3. Other speeds unaffected.	No effect.	3

**Table 5. ELECTRICAL FMEA - VAB Low Bay Checkout Cells 1, 2 and 4**

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**System/Subsystem:** VAB Low Bay Checkout Cells 1, 2 and 4 Bridge Cranes/Electrical  
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Find No. Part No.	Part Name	Part Function	a. Failure Mode b. Cause c. FMN d. Detection Method e. Correcting Action f. Time to Effect g. Timeframe	Failure Effect On System Performance	Failure Effect On Vehicle Systems And/Or Personnel Safety	Crit Cat
TD1	Time delay relay (hoist) speed-4	Time delay for resistor bank bypass	Any one contact fails closed	Speed 1 and 2 higher than normal. Speeds 3, 4, and 5 unaffected. See groundrule 3a.	No effect.	3
			Any one contact fails open	Loss of speed 3. Speed 3 is lower than normal	No effect.	3
			Relay fails open / short	Loss of speeds 4 and 5. Other speeds unaffected.	No effect.	3
			Contact fails closed	The delay between speeds 3 and 4 will not occur.	No effect.	3
			Contact fails open	Loss of speeds 4 and 5. Other speeds unaffected.	No effect.	3
4A	Contactor relay (hoist) speed-4	Resistor bank bypass	Relay fails open / short	Loss of speed 4. Other speeds unaffected.	No effect.	3
			Contact fails closed	Hoist may operate at higher speed than commanded. Hoist will operate at speed 4 when speed 1, 2, 3 or 4 is commanded. Speed 5 unaffected. See groundrule 3a.	No effect.	3
			Contact fails open	Loss of speed 4. Other speeds unaffected.	No effect.	3
			Any one contact fails closed	Speeds 1, 2 and 3 higher than normal. Speeds 4 and 5 unaffected. See groundrule 3a.	No effect.	3

Table 5. ELECTRICAL FMEA - VAB Low Bay Checkout Cells 1, 2 and 4						Pages 16 to 41
System/Subsystem: VAB Low Bay Checkout Cells 1, 2 and 4 Bridge Cranes/Electrical PMN: K60-0391					Drawing No.: 79K16767 Reference: None	
Find No. Part No.	Part Name	Part Function	a. Failure Mode b. Cause c. FMN d. Detection Method e. Correcting Action f. Time to Effect g. Timeframe	Failure Effect On System Performance	Failure Effect On Vehicle Systems And/Or Personnel Safety	Crit Cat
TD2	Time delay relay (hoist) speed-5	Time delay for resistor bank bypass	Any one contact fails open	Loss of speed 4. Other speeds unaffected. Speed four is lower than normal.	No effect.	3
			Relay fails open / short	Loss of speed five.	No effect.	3
			Contact fails closed	The delay between speeds 4 and 5 will not occur.	No effect.	3
5A	Contactor relay (hoist) speed-5	Resistor bank bypass	Contact fails open	Loss of speed 5.	No effect.	3
			Relay fails open / short	Loss of speed 5. Other speeds unaffected.	No effect.	3
			All contacts fails closed	Hoist will operate at speed 5 at all times. See groundrule 3a.	No effect.	3
			All contacts fails open	Loss of speed 5. Other speeds unaffected.	No effect.	3
			Any one contact fails closed	Speeds 1, 2, 3, and 4 higher than normal. Speed 5 unaffected. See groundrule 3a.	No effect.	3
P	Contactor relay (trolley) speed-3	Resistor bank bypass	Any one contact fails open	Loss of speed 5. Other speeds unaffected. Speed 5 lower than normal.	No effect.	3
			Relay fails open / short	Loss of speed 2 other speeds unaffected.	No effect.	3

**Table 5. ELECTRICAL FMEA - VAB Low Bay Checkout Cells 1, 2 and 4**

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**System/Subsystem:** VAB Low Bay Checkout Cells 1, 2 and 4 Bridge Cranes/Electrical  
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**Drawing No.:** 79K16767**Reference:** None

Find No. Part No.	Part Name	Part Function	a. Failure Mode b. Cause c. FMN d. Detection Method e. Correcting Action f. Time to Effect g. Timeframe	Failure Effect On System Performance	Failure Effect On Vehicle Systems And/Or Personnel Safety	Crit Cat
TD5	Time delay relay (trolley) speed-3	Time delay for resistor speed 3 to begin.	Contact fails closed	Trolley may operate at higher speed than commanded. Trolley will operate at speed 2 when speed 1 is selected. Other speeds unaffected. See groundrule 3a.	No effect.	3
			Contact fails open	Loss of speed 2 other speeds unaffected.	No effect.	3
			Relay fails open/short	Loss of overcurrent protection. Possible damage to GSE.	No effect.	3
			Relay fails open / short	Loss of speeds 3, 4, and 5.	No effect.	3
			Contact fails closed	The delay between speeds 2 and 3 will not occur.	No effect.	3
3A1	Contactor relay (trolley) speed-3	Resistor bank bypass	Contact fails open	Loss of speeds 3, 4, and 5.	No effect.	3
			Relay fails open / short	Loss of speed 3. Other speeds unaffected.	No effect.	3
			Contact fails closed	Trolley may operate at higher speed than commanded. Trolley will operate at speed 3 when speed 1, 2 or 3 is commanded. Speed 4 and 5 unaffected. See groundrule 3a.	No effect.	3
			Contact fails open	Loss of speed 3. Other speeds unaffected.	No effect.	3
			Any one contact fails closed	Speed 1 and 2 higher than normal. Speeds 3, 4, and 5 unaffected. See groundrule 3a.	No effect.	3

Table 5. ELECTRICAL FMEA - VAB Low Bay Checkout Cells 1, 2 and 4						Pages 16 to 41
System/Subsystem: VAB Low Bay Checkout Cells 1, 2 and 4 Bridge Cranes/Electrical PMN: K60-0391					Drawing No.: 79K16767 Reference: None	
Find No. Part No.	Part Name	Part Function	a. Failure Mode b. Cause c. FMN d. Detection Method e. Correcting Action f. Time to Effect g. Timeframe	Failure Effect On System Performance	Failure Effect On Vehicle Systems And/Or Personnel Safety	Crit Cat
TD6	Time delay relay (trolley) speed-4	Time delay for resistor bank bypass	Any one contact fails open	Speed 3 lower than normal. All other speed unaffected.	No effect.	3
			Relay fails open / short	Loss of speeds 4 and 5.	No effect.	3
			Contact fails closed	The delay between speeds 3 and 4 will not occur.	No effect.	3
4A1	Relay (trolley) speed-4	Resistor bank bypass	Contact fails open	Loss of speeds 4 and 5.	No effect.	3
			Relay fails open / short	Loss of speed 4. Other speeds unaffected.	No effect.	3
			All contacts fail closed	Trolley may operate at higher Speed than commanded. Trolley will operate at speed 4 when speed 1, 2, 3 or 4 is commanded. Speed 5 unaffected. See groundrule 3a.	No effect.	3
			All contacts fail open	Loss of speed 4. Other speeds unaffected.	No effect.	3
			Any one contact fails closed	Speeds 1, 2 and 3 higher than normal. Speeds 4 and 5 unaffected. See groundrule 3a.	No effect.	3
TD7	Time delay relay (trolley) sped-5	Time delay for resistor bank bypass	Any one contact fails open	Speed 4 lower than normal. All other speeds unaffected.	No effect.	3
			Relay fails open / short	Loss of speed 5	No effect.	3
			Contact fails closed	The delay between speeds 4 and 5 will not occur.	No effect.	3

Table 5. ELECTRICAL FMEA - VAB Low Bay Checkout Cells 1, 2 and 4						Pages 16 to 41
System/Subsystem: VAB Low Bay Checkout Cells 1, 2 and 4 Bridge Cranes/Electrical PMN: K60-0391					Drawing No.: 79K16767 Reference: None	
Find No. Part No.	Part Name	Part Function	a. Failure Mode b. Cause c. FMN d. Detection Method e. Correcting Action f. Time to Effect g. Timeframe	Failure Effect On System Performance	Failure Effect On Vehicle Systems And/Or Personnel Safety	Crit Cat
5A1	Contactor relay (trolley) speed-5	Resistor bank bypass	Contact fails open	Loss of speed 5	No effect.	3
			Relay fails open / short	Loss of speed 5. Other speeds unaffected.	No effect.	3
			All contacts fail closed	Trolley will operate at speed 5 at all times. See groundrule 3a.	No effect.	3
			All contacts fail open	Loss of speed 5. Other speeds unaffected.	No effect.	3
			Any one contact fails closed	Speeds 1, 2, 3, and 4 higher than normal. Speed 5 unaffected. See groundrule 3a.	No effect.	3
P1	Contactor relay (bridge)	Resistor bank bypass	Any one contact fails open	Loss of speed 5. Other speeds unaffected. Speed 5 is slower than normal.	No effect.	3
			Relay fails open / short	Loss of speed 2 other speeds unaffected.	No effect.	3
			Contact fail closed	Bridge may operate at higher speed than commanded. Bridge will operate at speed 2 when speed 1 is selected. Other speed unaffected. See groundrule 3a.	No effect.	3
			Contact fail open	Loss of speed 2 other speeds unaffected.	No effect.	3
TD10	Time delay relay (bridge) speed-3	Time delay for resistor bank bypass	Relay fails open / short	Loss of speeds 3, 4, and 5.	No effect.	3

Table 5. ELECTRICAL FMEA - VAB Low Bay Checkout Cells 1, 2 and 4						Pages 16 to 41
System/Subsystem: VAB Low Bay Checkout Cells 1, 2 and 4 Bridge Cranes/Electrical PMN: K60-0391					Drawing No.: 79K16767 Reference: None	
Find No. Part No.	Part Name	Part Function	a. Failure Mode b. Cause c. FMN d. Detection Method e. Correcting Action f. Time to Effect g. Timeframe	Failure Effect On System Performance	Failure Effect On Vehicle Systems And/Or Personnel Safety	Crit Cat
3A2	Contactor relay (bridge) speed-3	Resistor bank bypass	Contact fails closed	The delay between speeds 2 and 3 will not occur.	No effect.	3
			Contact fails open	Loss of speeds 3, 4, and 5.	No effect.	3
			Relay fails open / short	Loss of speed 3. Other speeds unaffected.	No effect.	3
			All contacts fail closed	Bridge may operate at higher speed than commanded. Bridge will operate at speed 3 when speed 1, 2 or 3 is commanded. Speed 4 and 5 unaffected. See groundrule 3a.	No effect.	3
			All contacts fail open	Loss of speed 3. Other speeds unaffected.	No effect.	3
			Any one contact fails closed	Speed 1 and 2 higher than normal. Speeds 3, 4, and 5 unaffected. See groundrule 3a.	No effect.	3
TD11	Time delay relay (bridge) speed-4	Time delay for resistor bank bypass	Any one contact fails open	Speed 3 lower than normal. Other speeds unaffected.	No effect.	3
			Relay fails open / short	Loss of speeds 4 and 5.	No effect.	3
			Contact fails closed	The delay between speeds 3 and 4 will not occur.	No effect.	3
			Contacts fail open	Loss of speeds 4 and 5.	No effect.	3

Table 5. ELECTRICAL FMEA - VAB Low Bay Checkout Cells 1, 2 and 4						Pages 16 to 41
System/Subsystem: VAB Low Bay Checkout Cells 1, 2 and 4 Bridge Cranes/Electrical PMN: K60-0391					Drawing No.: 79K16767 Reference: None	
Find No. Part No.	Part Name	Part Function	a. Failure Mode b. Cause c. FMN d. Detection Method e. Correcting Action f. Time to Effect g. Timeframe	Failure Effect On System Performance	Failure Effect On Vehicle Systems And/Or Personnel Safety	Crit Cat
4A2	Contactor relay (bridge) speed-4	Resistor bank bypass	Relay fails open / short	Loss of speed 4. Other speeds unaffected.	No effect.	3
			All contacts fail closed	Bridge may operate at higher speed than commanded. Bridge will operate at speed 4 when speed 1, 2, 3 or 4 is commanded. Speed 5 unaffected. See groundrule 3a.	No effect.	3
			All contacts fail open	Loss of speed 4. Other speeds unaffected.	No effect.	3
			Any one contact fails closed	Speeds 1, 2 and 3 higher than normal. Speeds 4 and 5 unaffected. See groundrule 3a.	No effect.	3
			Any one contact fails open	Speed 4 lower than normal other speeds unaffected.	No effect.	3
TD12	Time delay relay (bridge)	Time delay for resistor bank bypass	Relay fails open / short	Loss of speed 5	No effect.	3
			Contact fails closed	The delay between speeds 4 and 5 will not occur.	No effect.	3
			Contact fail open	Loss of speed 5	No effect.	3
5A2	Relay (bridge) 5-speed	Resistor bank bypass	Relay fails open / short	Loss of speed 5. Other speeds unaffected.	No effect.	3
			All contacts fail closed	Will operate at speed 5 at all times. See groundrule 3a.	No effect.	3



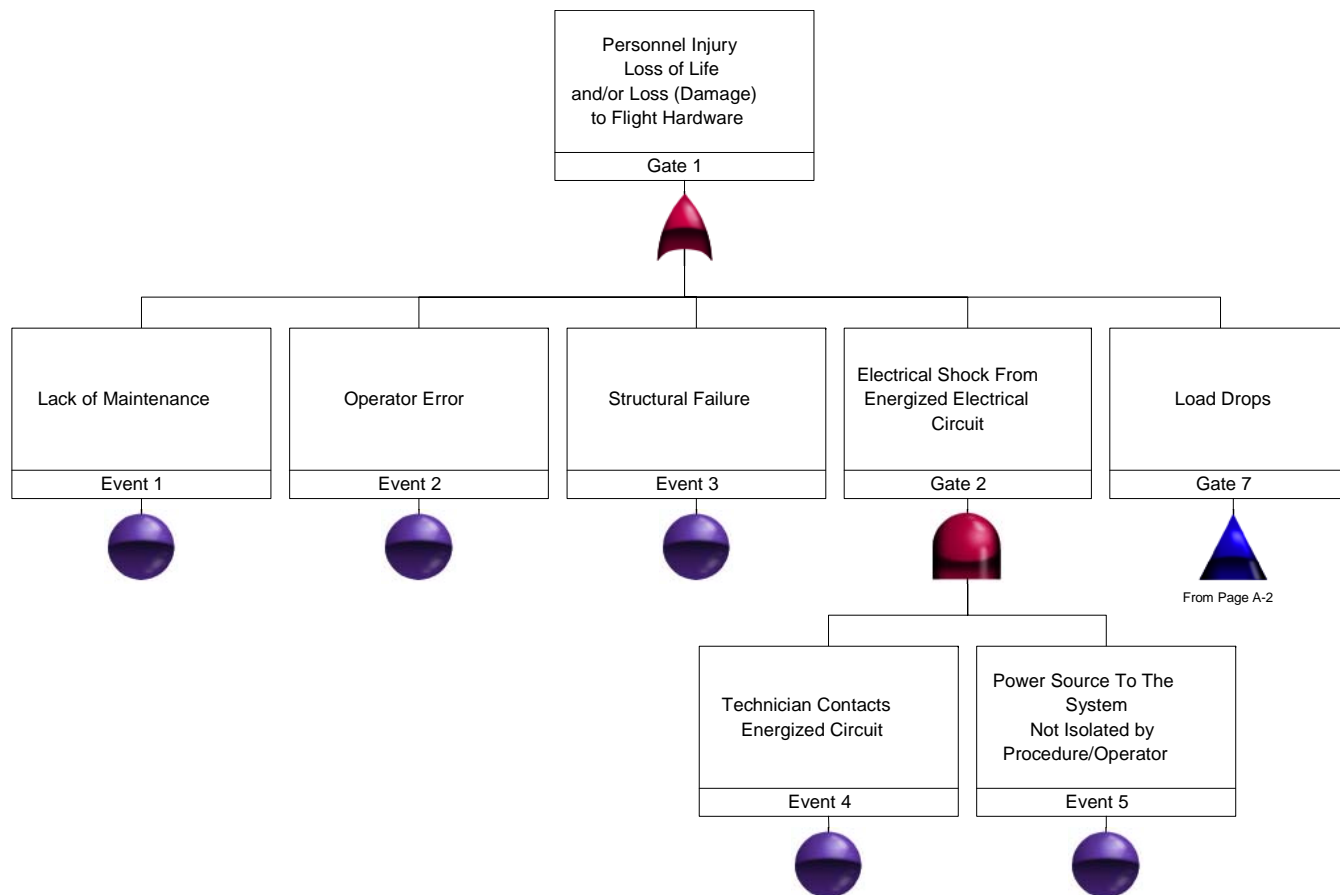
Table 5. ELECTRICAL FMEA - VAB Low Bay Checkout Cells 1, 2 and 4						Pages 16 to 41
System/Subsystem: VAB Low Bay Checkout Cells 1, 2 and 4 Bridge Cranes/Electrical PMN: K60-0391					Drawing No.: 79K16767 Reference: None	
Find No. Part No.	Part Name	Part Function	a. Failure Mode b. Cause c. FMN d. Detection Method e. Correcting Action f. Time to Effect g. Timeframe	Failure Effect On System Performance	Failure Effect On Vehicle Systems And/Or Personnel Safety	Crit Cat
PR	Relay, magnetic current (trolley)	Motor circuit overcurrent protection. Removes voltage to control logic relays.	All contacts fail open	Loss of speed 5. Other speeds unaffected.	No effect.	3
			Any one contact fails closed	Speeds 1, 2, 3, and 4 higher than normal. Speed 5 unaffected. See groundrule 3a.	No effect.	3
			Any one contact fails open	Speed 5 slower than normal. Other speeds unaffected.	No effect.	3
			Relay fails open / short	Loss of overcurrent cutout. Possible damage to motor during overcurrent condition. May occur undetected.	No effect.	3
			Contact fails open	Trolley will operate in speed 1 only.	No effect.	3
			Contact fail closed	Loss of overcurrent cutout. Possible damage to motor during overcurrent condition. May occur undetected.	No effect.	3
PR1	Relay, magnetic current (bridge)	Motor circuit Overcurrent protection. Removes voltage to control logic relays.	Relay fails open / short	Loss of overcurrent cutout. Possible damage to motor during overcurrent condition. May occur undetected.	No effect.	3
			Contact fails open	Bridge will operate in speed 1 only.	No effect.	3
			Contact fail closed	Loss of overcurrent cutout. Possible damage to motor during overcurrent condition. May occur undetected. Requires double failure.	No effect.	3

Table 5. ELECTRICAL FMEA - VAB Low Bay Checkout Cells 1, 2 and 4						Pages 16 to 41
System/Subsystem: VAB Low Bay Checkout Cells 1, 2 and 4 Bridge Cranes/Electrical PMN: K60-0391					Drawing No.: 79K16767 Reference: None	
Find No. Part No.	Part Name	Part Function	a. Failure Mode b. Cause c. FMN d. Detection Method e. Correcting Action f. Time to Effect g. Timeframe	Failure Effect On System Performance	Failure Effect On Vehicle Systems And/Or Personnel Safety	Crit Cat
M1	Hoist motor	Provides torque to turn the hoist drum	Inoperable	Hoist will not operate. Brakes will engage if failure occurs during operations.	No effect.	3
M2	Trolley motor	Provides torque to turn the trolley wheels	Inoperable	Trolley will not operate.	No effect.	3
M3	Bridge motor	Provides torque to turn the bridge wheels	Inoperable	Bridge will not operate.	No effect.	3
KS1	Bypass key switch	When the final upper limit switch is tripped this allows the hoist to be powered to lower the hook. Locks out "U" up relay.	N O Side Fails open	Normal position until tripped by FUL. Unable to lower the load or hook when the FUL is tripped.	No effect.	3
			N O Side Fails closed	Cannot move the hoist up due to the circuit opened by KS1 switch.	No effect.	3
FULS	Final Upper Limit switch	Final limit switch. Weighted switch on wire rope hook. Deenergizes mainline contactor to prevent two-blocking.	Fails open	Cannot power the hoist.	No effect.	3
			Fails closed	Loss of safety switch to prevent two-blocking. Requires prior failure of GULS.	No effect.	3

## **Appendix A. FAULT TREE AND HAZARD ANALYSIS**

The Fault Tree Analysis and Hazard Analysis Worksheets follow.

There are no Hazard Reports associated with this system.



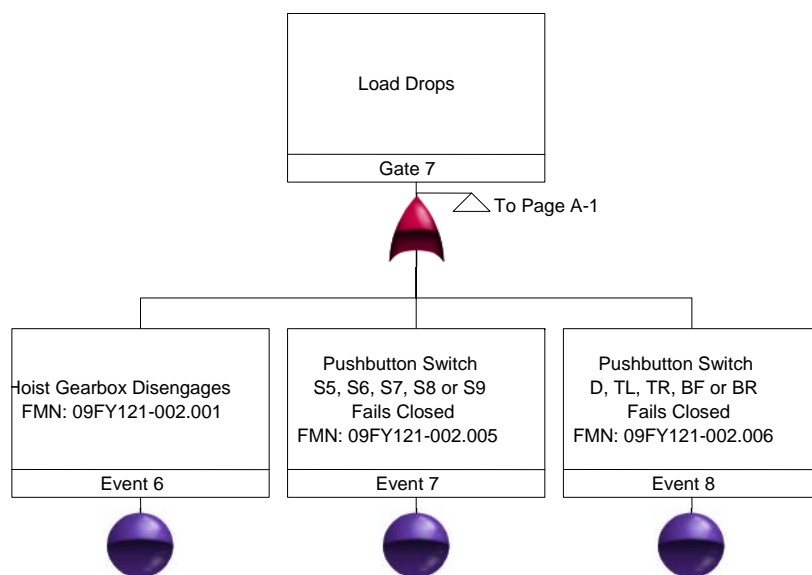


Table 6. Hazard Analysis Worksheet – VAB Low Bay 10 Ton Cranes			Pages A-3 to A-3
System/Subsystem: VAB Low Bay Checkout Cells 1, 2 and 4 Bridge Cranes			Location:
Gate No. Hazardous Condition	Severity	Event No. Event Nomenclature (Hazard Cause)	Safety Requirements & Hazard Cause Control Provision/Verification
Gate 1 Personnel Injury/Loss of life and/or Loess (Damage) to Flight hardware	CA	Event 1 Lack of Maintenance	Annual maintenance of hoist gearbox includes inspection for damage/corrosion, loose fasteners, oil leakage, oil level and oil sampling per OMI Q6166.
	CA	Event 2 Operator Error	Operator error is minimized through proper training and certification. Proper certification verified per OMI V5087.
	CA	Event 3 Structural Failure	Load test performed annually per OMI Q6166.
	CA	Event 4 Technician Contacts Energized Circuit	Operator error is minimized through proper training and certification. Proper certification verified per OMI V5087.
	CA	Event 5 Power Source To The System Not Isolated by Procedure/Operator	KNPR 8715.3 "KSC Safety Practices Procedural Requirements", USA Ground Operations Operating Procedure, USA002433 "Lockout/Tagout and Do Not Use or Operate Programs" states that all affected, authorized, and other employees shall annually complete two training courses: QG20A-LSC, "Site/Area Specific Safety Training and QG111-LSC, "Lockout/Tagout". Personnel will lockout and tag any system prior to de-energization.
	CR	Event 6 Hoist Gearbox Disengages FMN: 09FY121-002.001	See CIL Sheet
	CR	Event 7 Pushbutton Switch, S5, S6, S7, S8 or S9 Fails Closed FMN: 09FY121-002.005	See CIL Sheet
	CR	Event 8 Relay D, TL, TR, BF or BR Contacts Fail Closed FMN: 09FY121-002.006	See CIL Sheet

## **Appendix B. CRITICAL ITEMS LIST**

**USA Ground Operations CIL Sheet****Critical Item:** Pushbutton Switch**NASA Part No:** None**Mfg/Part No:** Duct-O-Wire / PB-5**System:** 010-Ton Bridge Crane**Criticality Category:** 2**Total Quantity:** 15

Find No.	Qty	Area	PMN	Baseline	Drawing / Sheet
S5	1	VAB CC-1	K60-0531	389.00	79K16767 / 3
S5	1	VAB CC-2	K60-0531	389.00	79K16767 / 3
S5	1	VAB CC-4	K60-0531	389.00	79K16767 / 3
S6	1	VAB CC-1	K60-0531	389.00	79K16767 / 3
S6	1	VAB CC-2	K60-0531	389.00	79K16767 / 3
S6	1	VAB CC-4	K60-0531	389.00	79K16767 / 3
S7	1	VAB CC-1	K60-0531	389.00	79K16767 / 3
S7	1	VAB CC-2	K60-0531	389.00	79K16767 / 3
S7	1	VAB CC-4	K60-0531	389.00	79K16767 / 3
S8	1	VAB CC-1	K60-0531	389.00	79K16767 / 3
S8	1	VAB CC-2	K60-0531	389.00	79K16767 / 3
S8	1	VAB CC-4	K60-0531	389.00	79K16767 / 3
S9	1	VAB CC-1	K60-0531	389.00	79K16767 / 3
S9	1	VAB CC-2	K60-0531	389.00	79K16767 / 3
S9	1	VAB CC-4	K60-0531	389.00	79K16767 / 3

**Function:**

Energizes control relays for trolley or bridge and hoist down function.

Failure Mode No. Failure Mode	Failure Cause Failure Effect	Detection Method Time to Effect	Crit Cat
09FY121-002.005  Fails closed	Switch sticks, hoist function, welded contacts, broken spring  Hoist, trolley or bridge will not cease operation in the last commanded direction unless commanded by the stop, remote stop, disconnect switches or a limit switch. Possible loss (damage) to flight hardware if close proximity to an obstruction.	Audible, Visual  Seconds	2

**ACCEPTANCE RATIONALE****Design:**

- Two push button switches per module, two blades per switch, six contact balls per switch.
- NEMA 4 contacts, 120 VAC, 0.25 amps continuous, 1.9 amps intermittent.

**Test:**

- Pre-operational set up to support lifting operations in OMI V5087 verifies proper operation of crane components and all functions.
- A full operational check of the crane is performed monthly (no load) in accordance with OMI Q6166.
- An operational check of the crane is performed under full rated load as part of the annual load test in accordance with OMI Q6166.
- OMRSD File VI requires annual performance of an operational test at rated load.



**USA Ground Operations CIL Sheet**

- Reliability testing was performed by the manufacturer. This type switch was subjected to over 500,000 cycles without failure.

**Inspection:**

- The pendant control is visually inspected monthly for missing nomenclature and physical damage such as loose screws, torn dust covers or damage pushbuttons in accordance with OMI Q6166.

**Failure History:**

- Current data on test failures, unexplained anomalies, and other failures experienced during ground processing activities can be found in the PRACA database. The PRACA database was researched and no data was found on this component in the critical failure mode.
- The GIDEP database was researched and no data was found on this component in the critical failure mode.

**Operational Use:**

Correcting Action	Timeframe
There is no action which can be taken to mitigate the failure effect.	Since no correcting action is available, timeframe does not apply.

**USA Ground Operations CIL Sheet****Critical Item:** Contactor Relay**Criticality Category:** 2**NASA Part No:** None**Total Quantity:** 15**Mfg/Part No:** Telemecanique(ITE) / 2200R-EBR230AA**System:** 010-Ton Bridge Crane

Find No.	Qty	Area	PMN	Baseline	Drawing / Sheet
BF	1	VAB CC-1	K60-0531	389.00	79K16767 / 3
BF	1	VAB CC-2	K60-0531	389.00	79K16767 / 3
BF	1	VAB CC-4	K60-0531	389.00	79K16767 / 3
BR	1	VAB CC-1	K60-0531	389.00	79K16767 / 3
BR	1	VAB CC-2	K60-0531	389.00	79K16767 / 3
BR	1	VAB CC-4	K60-0531	389.00	79K16767 / 3
D	1	VAB CC-1	K60-0531	389.00	79K16767 / 3
D	1	VAB CC-2	K60-0531	389.00	79K16767 / 3
D	1	VAB CC-4	K60-0531	389.00	79K16767 / 3
TL	1	VAB CC-1	K60-0531	389.00	79K16767 / 3
TL	1	VAB CC-2	K60-0531	389.00	79K16767 / 3
TL	1	VAB CC-4	K60-0531	389.00	79K16767 / 3
TR	1	VAB CC-1	K60-0531	389.00	79K16767 / 3
TR	1	VAB CC-2	K60-0531	389.00	79K16767 / 3
TR	1	VAB CC-4	K60-0531	389.00	79K16767 / 3

**Function:**

Energizes control relays for trolley or bridge and hoist down function.

Failure Mode No. Failure Mode	Failure Cause Failure Effect	Detection Method Time to Effect	Crit Cat
09FY121-002.006  All Relay contactors fail activated	Relay sticks welded contacts.  Hoist, trolley or bridge will not cease operation in the last commanded direction unless commanded by the stop, remote stop, disconnect switches or a limit switch. Possible loss (damage) to flight hardware if close proximity to an obstruction.	Audible, Visual  Seconds	2

**ACCEPTANCE RATIONALE****Design:**

- Three pole reversing contactor.
- Coil: 120V AC
- Contacts: 480V AC, 2.3 amps, made from silver silver cadmium oxide material.

**Test:**

- Pre-operational set up to support lifting operations in OMI V5087 verifies proper operation of crane components and all functions.
- A full operational test of the crane is performed monthly (no load) in accordance with OMI Q616.
- An operational check of the crane is performed under full rated load as part of the annual load test in accordance with OMI Q6166.
- OMRSD File VI requires annual performance of an operational test at rated load.

**USA Ground Operations CIL Sheet****Inspection:**

- Relay contactors are inspected for wear and pitting monthly in accordance with OMI 46166.

**Failure History:**

- Current data on test failures, unexplained anomalies, and other failures experienced during ground processing activities can be found in the PRACA database. The PRACA database was researched and no data was found on this component in the critical failure mode.
- The GIDEP database was researched and no data was found on this component in the critical failure mode.

**Operational Use:**

Correcting Action	Timeframe
There is no action which can be taken to mitigate the failure effect.	Since no correcting action is available, timeframe does not apply.

**USA Ground Operations CIL Sheet****Critical Item:** Hoist Gearbox Assembly**Criticality Category:** 2**NASA Part No:** None**Total Quantity:** 3**Mfg/Part No:** Yale Engineering Co. / LE10G40FB10**System:** 010-Ton Bridge Crane

Find No.	Qty	Area	PMN	Baseline	Drawing / Sheet
None	1	VAB CC-1	K60-0531	389.00	79K16767 / 3
None	1	VAB CC-2	K60-0531	389.00	79K16767 / 3
None	1	VAB CC-4	K60-0531	389.00	79K16767 / 3

**Function:**

Transmits power from the hoist motor to the wire rope drum.

Failure Mode No. Failure Mode	Failure Cause Failure Effect	Detection Method Time to Effect	Crit Cat
09FY121-002.001 Gear disengagement	Structural failure of gears, shafts, mechanical load brake components, and the gearbox housing  Load (Flight Hardware) suspended from hoist will drop.	Audible, Visual  Seconds	2

**ACCEPTANCE RATIONALE****Design:**

- The gear box is an off-the-shelf item manufactured by Yale Industries. Its design complies with Crane Manufacturers Association of America (CMAA) specification # 70.
- All gearing design is based upon AGMA standards 220.02, "Rating of the Strength of Spur Gear Teeth" and 210.02, "Surface Durability (pitting) of Spur Gear Teeth."
- The gears are splined to shafts or integrally machined and are retained in place by shoulders within the confines of the gearbox.
- Load bearing members, such as the gear case and shafts, have been designed so that the calculated static stress, based upon the rated load, does not exceed 20% of the average ultimate strength of the material, i.e. 5:1 factor of safety.

**Test:**

- Pre-operational set up to support lifting operations in OMI V5087 verifies proper operation of crane components and all functions.
- A load test at 100% of rated load is performed annually by OH1 Q6166 in accordance with NASA-STD-8719.9 requirement.
- OMRSD File VI requires annual performance of a rated load test to verify system integrity.
- An annual operational check of the hoist is performed under full rated load in accordance with OMI 46166.
- A full operational check of the hoist is performed monthly (no load) in accordance with OMI Q6166.

**Inspection:**

- The hoist gearbox is checked annually per OMI No. Q6166 for damage, corrosion, loose fasteners, oil leakage, oil level.

**Failure History:**

- Current data on test failures, unexplained anomalies, and other failures experienced during ground processing activities can be found in the PRACA database. The PRACA database was researched and no data was found on this component in the critical failure mode.
- The GIDEP database was researched and no data was found on this component in the critical failure mode.

**Operational Use:**

Correcting Action	Timeframe
There is no action which can be taken to mitigate the failure	Since no correcting action is available,

**USA Ground Operations CIL Sheet**

effect.	timeframe does not apply.
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